# Giving Priority Access to Freight Vehicles at Signalized Intersections

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Deceleration and acceleration of vehicles have a large impact on pollution and on waiting times. This is even more outspoken for freight vehicles, as they have much longer acceleration times and higher pollution levels than regular vehicles. Therefore, it makes sense to avoid, as much as possible, that freight vehicles have to stop at intersections. Note that this can also be beneficial for regular vehicles, as they have a lesser chance of getting stuck behind a freight vehicle at an intersection.

We concentrate on signalized intersections in this abstract. The aim is to give freight vehicles a high probability of green-light passage. This can be done by extending standard actuated control signals. First, freight vehicles should be detected. This can be done through sensing traffic and distinguishing freight vehicles from regular vehicles (by means of height, weight, ...). A future and promising alternative is active identification of freight vehicles by means of V2I (Vehicle-to-Infrastructure) communication. Second, an algorithm is required to decide whether the freight vehicle can be given a green light or not. This algorithm should be based on efficiency of passage, fairness for all intersecting traffic streams and vehicle types, safety, ...

We analyze the effect of increasing the green-light probability for freight vehicles on the mean waiting times of freight and regular vehicles. We concentrate on a fairly simple algorithm and intersection configuration. We assume that within a complete green/red cycle of the intersection, one of the green periods can be extended for a fixed period if freight vehicles are approaching. Obviously, the concurrent red periods are extended as well. We model separately each stream passing the intersection, where we assume that all vehicles that use the same lane make up one stream. So for a regular four-way intersection with separate turn lanes, we have 12 streams (4 origins and 3 destinations per origin). We further assume that a stream that is given a green light can pass the intersection without interference of other streams.

To model the streams, we group them in two categories: streams that benefit (category 1) and streams that suffer (category 2) from the extended green time for freight vehicles. As a first model, we assume independent Poisson arrivals for regular vehicles and freight vehicles in each stream. A generic stream of category 1 is modeled as follows: freight vehicles arrive at rate $\lambda_f$, regular vehicles at rate $\lambda_r$. Without the extension of the green period, the stream sees cycles of free flow (green light; duration $t_g$ seconds) and blocked access (red or yellow light; duration $t_r$ seconds). The green light is extended for a period of $t_{eg}$ seconds if at least one freight vehicle of the streams of category 1 arrives during this period. A generic stream of category 2 has similar parameters; the main difference is that the red period of these streams is extended when the green period of the streams of category 1 is extended.

We analyze the mean waiting times of regular vehicles and freight vehicles in generic streams of both categories (i.e., 4 different analyses and end formulas). Since we expect that the algorithm will have the biggest effect in a light-traffic scenario, we assume that no waiting time is added by the intersection when a vehicle arrives during a green period. When arriving in a red period, the waiting time of a vehicle consists of the time until the traffic sign turns green and the time until the vehicle passes the traffic light after it turns green. The latter depends on the number of vehicles in front of the vehicle when the traffic light turns green and the speed with which the vehicle can leave the intersection. Since we assume slower discharge speeds for freight vehicles than for regular vehicles, the latter, in turn, depends on whether the vehicle itself is a freight vehicle and/or whether at least one freight vehicle is in front of the vehicle.

The analyses exist of conditioning and calculating conditioned mean waiting times, but is in essence rather straightforward. We are in particular interested in the difference between mean waiting times in this scenario with extended green periods and mean waiting times when traffic control is static. Although the latter could be analyzed more accurately (for instance by using results from polling models), we propose to calculate the latter simply by substituting the green period extension $t_{eg}$ by 0 in the expressions of the former scenario. The advantage of this approach is that both results suffer from the same approximation error.

The obtained formulas are explicit in the parameters of the model and can therefore easily be used to assess the impact of the extension length $t_{eg}$ (and other parameters) on the mean waiting times of different streams. Furthermore, they can also be used in an optimization function to find the optimal $t_{eg}$.

In future, we will concentrate on extending the analysis to also deal with overflow during a red/green cycle. Relaxing the independent Poisson arrival processes to dependent platooning arrival processes is another interesting research direction.